RESEARCH OF INFLUENCE OF PARAMETERS OF PROCESSING OF THE EGG OMELET OF LONG–TERM STORAGE BY THE HIGH PRESSURE ON ITS CONSUMER AND TECHNOLOGICAL PROPERTIES

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Summary. The paper gives the results of the egg omelets high pressure processing parameters effect (value of pressure, temperature and duration of treatment) and its prescription for microbiological safety of the product during its long–term storage, compression and rheological properties, water activity. Lagrange method was used to find the optimal settings to ensure high consumer characteristics of the product at its long–term storage.
Keywords: egg omelets, storage life, high pressure.

Relevance of research

Chicken eggs are one of the most valuable human foods and are used in the preparation of a large number of dishes, including leading place egg omelets (EO). Unfortunately, this product is not intended for long–term storage, and is preparing to mass catering facilities as needed. At the same time, because of products high nutritional value subject to its high nutritional and consumer properties for long–term storage, it can be recommended for use in camping trips and expeditions, remote regions of the country, the formation of strategic reserves of the armed forces and navy, as well as in the food industry and public catering enterprises.

The most suitable for the EO development of long–term storage production process to use high pressure (HP), which provides a microbiological safety of the products during storage, while maintaining high consumer qualities [1].

The purpose of work is to investigate the influence of HP processing parameters on EO consumer and technological properties, to determine the optimal process parameters to ensure EO high quality in its long–term storage.

To assess consumer and technological properties long–term storage EO were used:

– water activity (aw) – description of the product presented by the chemical composition of its hygroscopic properties characterizing the suitability of the product for long–term storage and defines a number of technological and consumer properties [2];

– the comprehensive indicator of EO quality defined on the basis of organoleptic evaluation expert methods;

– a set of compression and the rheological parameters: rate of penetration, the maximum shear stress, cutting work, density, relative volume, compression ratio, bulk compression modulus (volume elasticity modulus).

Object of research

To study the HP effect on egg products on the basis of liquid chicken eggs there was developed the EO production process with cheese, bacon, prolonged storage fried mushrooms, which comprises from mixing of liquid chicken eggs with shredded or diced cheese (or other ingredients), xanthan gum, which gives the finished product molded retention of water or milk, adding spices (salt, pepper), after which the resulting mixture is packed in airtight packaging resilient material, heated, dipped into the cooking chamber, the HP installation. As a result, the product was loaded into the HP working chamber with the temperature of 85–95°C, and after the consequent increase of working chamber pressure provided the treatment temperature at 110–130°C.

The EO production process using HP was investigated in the range of parameters: preheating a mixture at 85–95°C, treatment at 650–750 MPa pressure, duration of treatment – to 8 minutes.

Methodical hardware

The studies were performed on the basis of problem research laboratory "The use of high pressure in food technology," faculty technology products laboratories in the food sector and the Department of engineering disciplines in Donetsk National University of Economics and Trade named after Mykhailo Tugan–Baranovsky (high pressure research complex) [3], laboratories of the Food Resources Institute of Lugansk National Agrarian University.

The EO water activity was measured according to DSTU ISO 21807 "Microbiology of food and animal feed – Determination of water activity" on a portable speed device AquaLab Series 3TE (USA) with measurement accuracy ± 0,003 and beyond the aw measurement permissible absolute error – ± 0,006. The indicators research of "penetration rate", "limit cutoff voltage" and "cutting work" were performed on electromechanical universal testing machine SANS CMT2503 of "Shenzhen SANS Testing Co. Ltd" (China). Microbiological analyzes were performed in the Donetsk Sanitary Epidemiologic Station laboratories.

In this work we have used the standard methods of conducting experiments and the results evaluation.

Studies were performed in two stages: the first stage was to study the effect of process parameters and the individual components of EO prescription on their consumer and technological properties; the second stage – optimized the EO prescription and HP processing parameters to ensure high consumer properties during prolonged storage/ Measurements of all monitored parameters were repeated three times. The experiments error in all the series did not exceed 3%.

Results and discussion

It has been established that the inclusion in the omelet composition prescription produced using HP technology with xanthan gum in an amount up to 1.0% of the total weight of the mixture leads to an improvement of its structure: there was improved product uniformity, its elasticity and strength; omelet has richer color and approximate to the freshly prepared omelet color, produced by classical technology; more pronounced, natural, pure smell; natural, pure, distinct omelet taste. During long–term storage the product maintains its high consumer quality, in contrast to the control samples.

As a result of experimental studies of the process parameters influence on the HP EO processing to ensure microbiological safety against microorganisms such as mesophilic aerobic and facultative anaerobic microorganisms (molds); pathogens, including *Salmonella; psychrophilic bacteria Listeria seeligeri (Listeria innocua)*, *Pseudomonas fluorecens*, *Paenibacillus polymyxa*, coliforms (CGB), there were defined the process parameters values to ensure microbiological safety requirements within 6 months of storage.

Indicator of "coliforms" (CGB) is selected in accordance with the internationally accepted nomenclature; it is almost identical to "coliforms" terms. The study was considered on citrate–negative and CGB options citrate positive, including the following genera – *Escherichia, Klebsiella, Enterobacter, Citrobacter* and *Serratia*.

Analysis of experimental data on CGB inactivation showed that to describe the kinetics of inactivation of E. coli at site process parameters content it is appropriate to apply a two–phase model of the first order. This model consists of two parts that follow the first self–order kinetics [4,5].

Dependence of inactivation rate constants of the pressure was analyzed Arhenius–type model with the use of piecewise linear regression and obtained the values of points of discontinuity.

As a result the statistical analysis of the E. coli inactivation for all values of its parameters was described by the following function:

$$\begin{cases} \lg(N/N_0) = a + c\cdot(\tau - b);\ \tau < b \\ \lg(N/N_0) = a + d\cdot(\tau - b);\ \tau > b \end{cases}$$

where *a,c,d* – models coefficients that meet specific process parameters, *b* – point gap.

Mathematical description of the CGB inactivation process for different process values allowed to receive and analyze the obtained functions depending on inactivation rate pressure constants of $ln\ (k_1)$ and $ln\ (k_2)$.

To investigate the EO microbiological safety dynamics designs with cheese, bacon and mushrooms treated with HP during storage there were used samples, produced in the process parameters: 700MPa – 121°C – 6 min. The test samples were stored at 4°C ± 0,50 and the relative humidity from 85% to 88%, in a sealed package in which they were processed by HP.

Analysis of microbiological safety at these specifications showed that, within 6 months of storage the EO samples didn’t show the presence of: (coliforms) in 1.0 g, pathogenic, including *salmonella* in 25g, *S.aureus* in 1.0 g, *Proteus* in 0.1 g. After 5 and 6 months of storage there were found molds, CFU / g in an amount 1 on 105 and 1 on 104, which is significantly below permissible values for this indicator. There were not detected any psychrophilic bacteria of the *Listeria seeligeri species* (*Listeria innocua*), *Pseudomonas fluorecens* and *Paenibacillus polymyxa*.

Table 1 provides information on experimental research indicators of "penetration rate", "limit cutoff voltage", "work cutting".

Table 1 – The EO samples values of rheological parameters at P = 700 MPa and τ = 7×60s

EO indicators	with bacon	with cheese	with mushrooms
Penetration rate, kN/m^2	16,02	15,31	11,92
Limit cutoff voltage, kN/m^2	26,95	24,99	21,95
Work cutting, J	192	178	150,00

Average values of EO compression parameters change are as follows: relative volume at 700 MPa is reduced by 17,8–20,0%; density increases by 17,7–29,4%, bulk modulus increases by 84,6–169,3% and the volume compression coefficient is reduced by 87,5– 92,9%.

After depressurization the above indicators have the following values compared to their initial values: relative volume – 3,5–7,6%; density – 3,5–8,9%; bulk modulus – 37,0–161,3% and the volume compression coefficient – 72,1–79,6.

The water activity study was analyzed as index part depending on the process parameters and the evolution of this indicator in the EO long–term storage process produced by traditional technology and using the HP technology.

Experiments have revealed the following values: liquid water activity of chicken eggs before HP processing – 0,971 ± 0,004; egg omelet water activity, produced by traditional technology (EOt) – 0,903 ± 0,003.

An experimental results analysis in the Findgraph program established that the most appropriate for the mathematical description is linear functions using, graphs are shown in Figure 1.

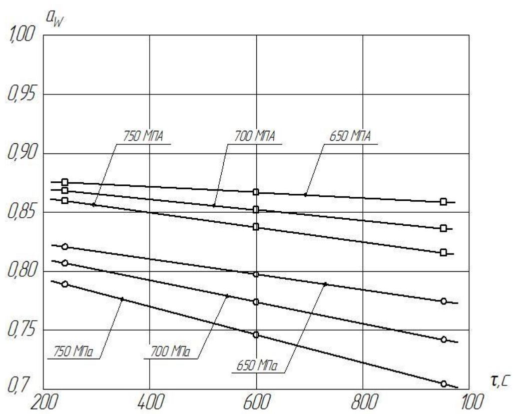

Fig. 1. The EO water a ctivity change made using HP, depending on process parameters: 1)for directly taken EO samples; 2)for EO samples after 6 month of its storage.

Analysis of research results and their mathematical description by (FindGraph program) the form function ($y = a + bx$) showed that EO HP treatment reduces the water activity values. The equation shows the part of standard deviation change of y rate in case of standard deviation change of x rate. This means that the greater the P, the more sensitive a_ω indicator of treatment duration.

Comparative changes analysis in the aw relative values in fresh product and after 6 month storage shows that there is a saturation process, which means that the P value further increase comes when the water activity will be unresponsive to this increase. Moreover, such product saturation after 6 months of storage may occur sooner compared with the manufactured product saturation. It is suggested that the water activity reduction in the HP treatment process was due to the moisture release from the processed product original weight and the more energy–intensive transition due to the dry substance – from free to bind.

Lagrange method was used to obtain the optimal process parameters and the produced product prescription composition, which allowed the experiment to evaluate the several factors integrated action effectiveness on the developed food product quality, namely, scrambled eggs with cheese. Dependent variables: y_1 – water activity (aw); y_2 – quality composite index (K), which is obtained by peer EO quality means. Factors affecting these parameters: x_1 – pressure (P, MPa); x_2 – temperature (t_0, C); x_3 – long–term treatment (τ, s); x_4 – water weight per 100 g of melange (g); x_5 – milk powder weight in 100g of melange (g); x_6 – xanthan gum (% of total mixture weight); x_7 – cheese weight in 100g of melange (g).

According to the Lagrange algorithm computational method there was built a equations system containing the objective function partial derivatives for all independent variables and undetermined Lagrange multipliers. MAPLE package 13 was used to solve the resulting equations system and receive the process parameters optimal values (Table 2).

Table 2 Optimum values for EO HP processing

Pressure, P, MPa	Temperature, t, °C	Treatment duration τ, s	Water weight per 100g of melange y, *g*	Milk powder weight in 100g of melange y, g	Xanthan gum (% of total mixture weight), *%*	Cheese weight in 100g of melange, g
x_1	x_2	x_3	x_4	x_5	x_6	x_7
691,5–695	120,2–123	425	14,04	13,58	0,747	25,5

Statistical analysis was completed by the model interpretation in terms of the study object following the experimental obtained optimal parameters verification and accuracy and reliability degree evaluation of optimization parameter values (Table 3).

The results of calculations for the given optimization parameters are presented as confidence intervals show that their experimental values do not exceed the respective intervals and thus confirm the results reliability.

Table 3 – Statistical authenticity evaluation of obtained results

Optimization parameter	Parameter value		Dispersion, S^2	Criteria t_p	Error, δ	Confidence interval
	y_i^p	y_i^e				
Water activity, (a_w)	0,786	0,748	0,0045	1,79	0,048	0,738–0,834
Comprehensive quality score (K)	0,98	0,941	0,005	1,74	0,051	0,929–1,0

Conclusions

A research result established the influence character of EO process parameters using HP and the test product prescription on its consumer and technological properties. There were determined optimum values providing high consumer quality of the product under its long–term storage.

The data obtained are of interest for the calculation methods development and HP installations design, process modeling in ANSYS systems, EO packaging materials calculation and design and production equipment for the developed process implementation.

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